CASE TEACHING NOTES for "Is a Mars Sample Return Mission too Risky? A Public Hearing Case Study"

by
Troy D. Wood
Department of Chemistry
University at Buffalo
State University of New York

INTRODUCTION

This case study was written for a class of non-science majors at the junior and senior level enrolled in a course at the University at Buffalo called "Great Discoveries in Science." The case was presented at the end of the course, after the students had been introduced to some of the major scientific discoveries over a broad range of disciplines from quantum physics to planetary science. I chose the public hearing case method to promote discussion (and argument) among the students while they played the roles of senators and their aides. There were approximately 40 student participants.

Objectives

- To illustrate the importance of interdisciplinary efforts in scientific research.
- To examine how the scientific method is used to develop a scientific hypothesis, and how new information is used to reevaluate an existing hypothesis.
- To critically evaluate interpretations of experimental data through the labeled release and gas chromatography-mass spectrometry experiments on Viking. A point of emphasis is how different people draw different conclusions from the same data.
- To define the criteria needed to establish whether something is living.
- To raise general awareness of the planned Mars Sample Return Mission.
- To provide an understanding of how public hearings are used to shape science policy in the United States.
- To examine cost/benefit analysis and the element of risk in formulating public policy.
- To promote critical thinking for development of possible alternatives to the Mars Sample Return Mission as currently planned.

MAJOR ISSUES

In selecting the topic for this case, I have attempted to raise awareness of the planned Mars Sample Return Mission specifically and, more generally, of the question of whether there is life on Mars. Proponents of this mission, as illustrated by Dr. Grossman, claim either that there is little to no evidence of life on Mars, or that even if microbial life exists, the chances of accidental contamination of the Earth's ecosphere are remote. Furthermore, even if accidental contamination were to occur, the likelihood of Martian microbes being pathogenic is remote. Opponents of this mission, such as Dr. Dow, contend that the original labeled released experiments performed by Viking provide strong evidence that microbial life exists on Mars. They argue that there are numerous flaws with the gas chromatography-mass spectrometry (GC-MS) experiments done by Viking, which detected no organic molecules, and point to the fact that organic molecules were detected in the ancient Martian meteorite ALH84001

recovered from Antarctica. Furthermore, opponents point out that scientists know much more about the diversity of life in extremophilic environments (like Antarctica) that resemble conditions on Mars than at the time of Viking. In addition, they argue that recent images acquired by Mars Observer coupled with theoretical calculations support the hypothesis that liquid water, seemingly necessary for life, can exist on Mars's surface. A third viewpoint comes from Dr. Cruz, whose analysis filters out the extremist elements of the other experts.

Both sides agree on two points from the Viking missions: radiolabeled CO_2 was evolved in the labeled release experiment, and that the GC-MS detected no organic molecules. However, there are vastly different interpretations on what the results imply. This points out one of the objectives of this case study, to demonstrate how different scientific conclusions can be drawn from the same sets of data.

A key element of this case study is the evolution of a scientific hypothesis over time. While after the Viking missions, the "oxidant" hypothesis was generally accepted to explain the absence of detection of organic molecules by GC-MS, in recent years many problems with the GC-MS device have been illustrated that could also account for the Viking results. In addition, organic molecules were detected in a meteorite that has become widely (but not universally) accepted as being of Martian origin. The past 25 years have also illustrated that virtually every niche of Earth's ecosphere, no matter how inhospitable, harbors life, making it easier to accept that evolutionary forces might permit some form of microbial life to adapt to conditions on Mars necessary for survival. Also, there is growing evidence that conditions on Mars might permit liquid water to exist. Taken together, this evidence suggests that Mars is not nearly as inhospitable as scientists first thought.

In conclusion, this case attempts to give students a broad perspective on a current scientific and public policy controversy regarding life on Mars and a Mars Sample Return Mission. It begs the students to ask the question, "Is such a mission worth it?" Students are asked to assess the benefits of discovering possible Martian life in relation to the risks such life might pose to Earth. In the two classes where I have taught this case, students have ultimately proposed an alternative mission in which samples taken from Mars would be returned to the international space station for analysis before considering a return to Earth's surface. As proposed, this was a compromise between the quest for new knowledge and the potential risk to Earth's ecosphere. However, only one of the two classes adopted this as their recommended action to NASA; the other class voted to continue funding the mission as planned. This also emphasizes the importance of risk/benefit analysis in developing public science policy.

CLASSROOM MANAGEMENT

This case study is presented in two parts: a drama consisting of a scripted public hearing and a backroom discussion by senators and their staff afterward. Three students are chosen to play the roles of the three scientific experts, with the instructor serving as Senator O'Neil. The rest of the students are given handouts of the background material and given five to ten minutes to read this material. Meanwhile, the instructor reviews the drama with the student actors. Special emphasis should be made to the student actors on how to pronounce some of the scientific terms; this should be done, if possible, in the hallway (if it is sufficiently quiet). Ideally, the student actors should be chosen in the class prior to the case study and given a script then in order to review it beforehand.

After the background material has been reviewed, the student actors and the instructor return. Ideally, the student actors sit at a table together in the front of the room facing the class. The instructor, as Senator O'Neil, either sits at a chair or stands at a podium up front and addresses the student actors and the drama is performed. Then, the instructor, assuming the role of Senator O'Neil, leads a 25- to 30-

minute discussion with the entire class (who act as senators and their aides) on the issues raised. The ultimate goal of this discussion is to decide whether the Mars Sample Return Mission is worthy of funding or not, and whether any modifications to the current mission plan can be implemented. Some leading questions the instructor may use to help reach this goal are:

1. How does one define life and what are the characteristics of living organisms?
2. Is it plausible living organisms can exist under extreme conditions like those currently found on Mars?
3. Are the possible problems with the GC-MS capable of preventing detection of organic molecules on Mars?
4. How strong is the evidence to support the oxidant hypothesis for destruction of organic molecules in Martian soils?
5. Are the labeled release experiments from Viking credible evidence of microbial life?
6. What is the likelihood of existing life on Mars?
7. How probable is it that pathogenic Martian organisms exist?
8. Could alterations be made to the mission plan that would pose less risk to Earth-borne life?

Interestingly, both classes to date decided it was “very possible” that life exists on Mars. Both classes also suggested that the senators should recommend an alteration in the mission plan, in which Martian soil should be brought back to the International Space Station for analysis and remain in quarantine until shown to be safe. One class selected this alternative as the recommended action. The other class ultimately decided to proceed with the Mars Sample Return Mission as it is currently planned.

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Image Credit: Image of Mars taken by the Hubble Telescope on June 26, 2001. Upon its release date (July 5, 2001), this photograph was considered in many circles to be the "best" photograph ever taken of the Red Planet from an Earth-based telescope. NASA and The Hubble Heritage Team (STScI/AURA). Acknowledgment: J. Bell (Cornell U.), P. James (U. Toledo), M. Wolff (Space Science Institute), A. Lubenow (STScI), J. Neubert (MIT/Cornell). Image and further details can be viewed at http://hubblesite.org/news_.and._views/pr.cgi.2001+24.

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